DEPARTMENT OF COMMERCE
LUTHER H. HODGES, Secretary

WEATHER BUREAU
F. W. REICHELDERFER, Chief

MONTHLY WEATHER REVIEW

JAMES E. CASKEY, JR., Editor

Volume 90, Number 9 | Washington, D.C. | SEPTEMBER 1962

HURRICANE MOVEMENT AND VARIABLE LOCATION OF HIGH INTENSITY SPOT IN WALL CLOUD RADAR ECHO

S. NEUMAN and J. G. BOYD
U S Weather Bureau, Miami, Fla.

[Manuscript received May 29, 1962]

1. INTRODUCTION

A study of hurricane eye fixes, as determined by radar, indicates that the center does not move in a smooth path, but in a sharp zig-zag course, as for Donna 1960 (fig. 1); sometimes the path appears almost cycloidal, as for Carla 1961 (fig. 2). Senn [1] recently discussed the rapid lateral variations in the center position, and Yeh [2] in 1950 described such oscillations as sinuous, and ascribed their causes to internal forces.

These oscillations become of major importance as a hurricane approaches the coast, since this could determine the area of greatest damage. The prediction of such oscillations is now only possible on a persistence basis (Dunn and Miller [3]). The present study of the radarscope film of hurricanes Donna and Carla, from Miami and Galveston, respectively, was made to test a method by which the radar meteorologist might determine the current direction of movement of the center along such an oscillating path. The method involves determining the zone of maximum echo intensity present in the wall cloud around the eye.* It is hypothesized that this area of maximum reflectivity occurs in the region of greatest ascending motion and low-level mass convergence. This often coincides with the region of maximum pressure falls, toward which there should be a component of motion (i.e., the "propagation" referred to by Hoover [4]). In hurricanes this is also a region of maximum influx of angular momentum. Pfeffer [5] has shown that hurricanes move in the direction of maximum transport of angular momentum. Also Shebayana [6] demonstrated that typhoons move to the region of maximum lower-level convergence.

*Determination of the most intense sector of the wall cloud can readily be accomplished by gain reduction, or by use of the attenuators present in the WSR-57.

2. ANALYSIS

During the period when Donna was southeast of Miami (fig. 1), and before it crossed the Florida Keys, some type of intensity oscillation was noted in that portion of the wall cloud visible on the WSR-57 at Miami. This more intense spot or area, with horizontal dimensions of about 3 to 5 miles, oscillated along the wall cloud arc, varying in azimuth from east to west. Figure 3, taken from the Carla film, illustrates the appearance of the spot.

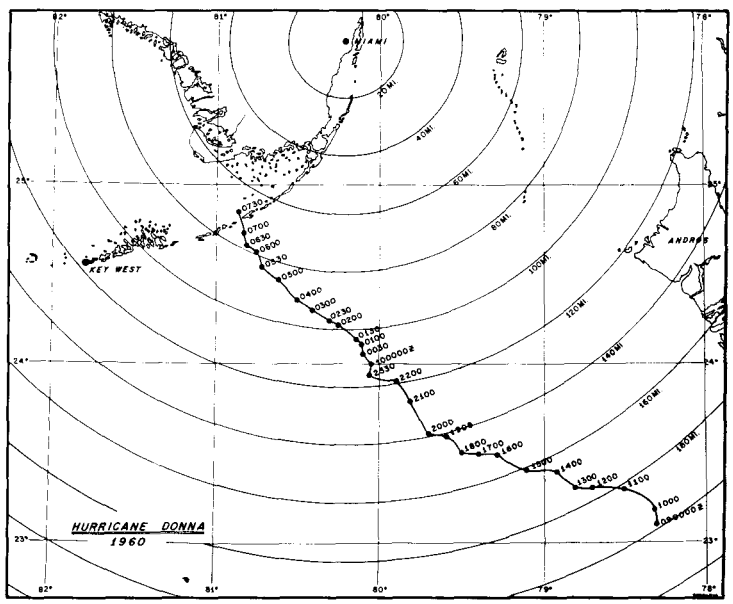

FIGURE 1.—Path of hurricane Donna, 0000 GMT, September 9 to 0700 GMT, September 10, 1960.

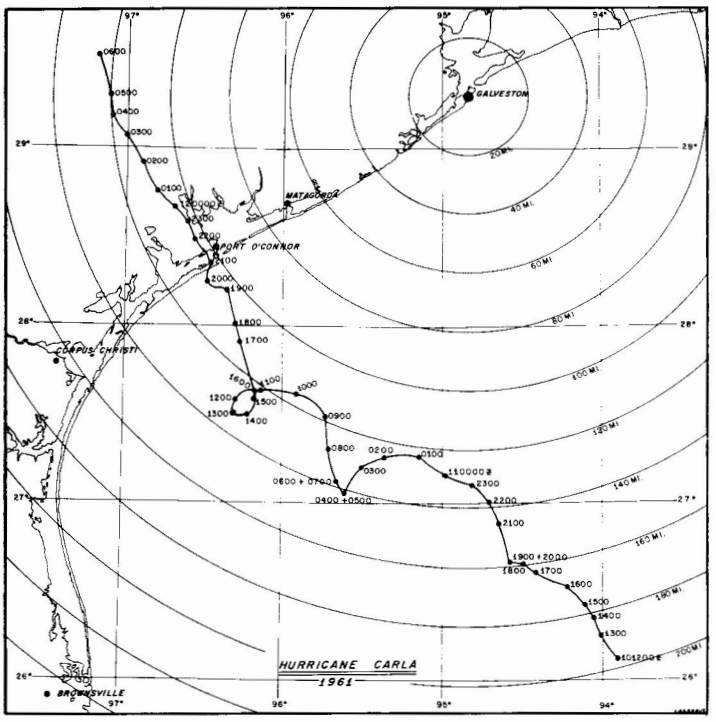

FIGURE 2.—Path of hurricane Carla, 1200 GMT, September 10 to 0600 GMT, September 12, 1961.

A study of the radarscope film of Donna was made to ascertain whether some correlation could be made between the position of this spot, or crescent-shaped area, and the erratic movements of the center. For the most part this proved difficult because of the time element. The oscillating cycle of the intense area ran to the order of 5 to 10 minutes, whereas the eye fixes were taken at half-hour or hour intervals. An attempt to determine eye fixes from the film for every 5 to 10 minutes proved impracticable. It was felt, however, that since the main track of Donna was persistent for varying lengths of time, an examination of the position of the most intense area during these periods could establish a relationship between the center movement and the movement of the intense spot or area.

Without reference to plotted eye fixes, data from the film were tabulated. (See table 1.) At approximately 8-minute intervals, the most intense portion of the wall cloud was noted, and the quadrant in which it was located was indicated to the nearest 8 points of the compass (N, NE, etc.). This is entered in table 1 after the time of each observation. These data were then reviewed, and the predominant position of the intense area was determined during the portions of persistent track movement. The conclusion drawn was that the direction of the center movement shifted toward the area of maximum intensity. For example, when there had been a change in the position of the intense area from N to NE, the center moved along a line east of the projection of its previous path. The deviations of the intense area

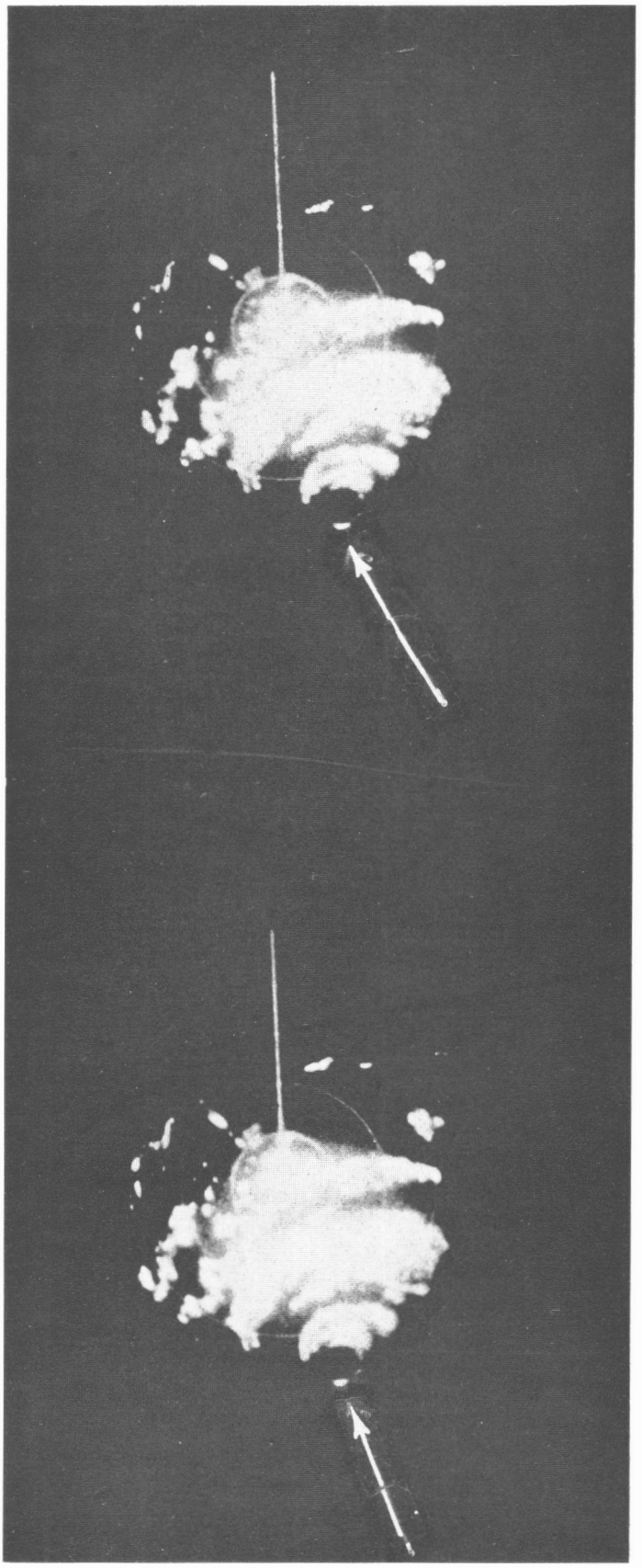

FIGURE 3.—Intense spot in radar echo of wall cloud of hurricane Carla, September 1961.

TABLE 1.—*Time and location of intense area in hurricane Donna wall cloud and deviation of eye and intense area*

Time (GMT)	Location of spot	Eye motion toward	Intense area sector
Sept. 9, 1960			
0902	N		
0908	NW		
0915	N		
0922	NE		
0930	N		
0938	NE		
0945	N		
0956	NW	NW (317)	N
1005	NE		
1017	N		
1020	NE		
1031	N		
1041	NW		
1045	N		
1052	NE		
1058	N		
1105	NW		
1111	NE		
1117	N		
1125	NW		
1134	N		
1145	NW		
1150	NW	W (270)	NW
1201	N		
1211	NW		
1214	NW		
1220	N		
1225	NE		
1230	N		
1237	NW		
1245	NE		
1250	NE		
1301	N		
1308	NW		
1315	N		
1320	NE	NW (312)	N
1325	N		
1330	NW		
1335	N		
1339	NE		
1344	N		
1351	NW		
1400	NW		
1405	N		
1410	NE		
1415	N		
1422	NW	W (270)	NW
1425	N		
1435	NE		
1440	N		
1447	NW		
1451	NW		
1456	N		
1501	NE		
1510	N		
1517	N		
1522	NW		
1529	NW		
1531	NE	NW (302)	NE
1537	N		
1541	NW		
1546	NE		
1550	NE		
1555	NE		
1602	NE		
1610	NE		
1615	N		
1624	NW		
1630	NW		
1633	N		
1638	NE		
1642	NE		
1655	N	W (272)	NNE
1707	NE		
1710	N		
1727	N		
1735	N		
1747	NE		
1755	N		
1800	NE		
1805	NE		
1817	N		
1821	NE		
1824	NE		
1834	NE	NW (314)	NE
1841	N		
1847	NW		
1851	NE		
1855	NE		
1905	NW		
1910	NW		
1919	SE		
1924	SE	W (271)	NNW
1932	NW		
1940	NE		
1945	N		
1951	N		
2001	N		
2005	N		
2010	NE		
2020	NE		
2025	NE		
2030	NE		
2035	NE		
2040	NE		
2047	N		
2054	N	NNW (330)	NE
2057	NE		
2101	NE		
2105	NE		
2110	NE		
2115	NE		
2118	N		
2120	N		
2125	NW		
2130	NW		
2135	NW		
2141	NW		
2145	NW		
2147	NW		
2201	NW	WNW (290)	NW
2224	NW		
2231	NW		
2238	NW		
2258	W		
2345	NW		
2348	NE		
2352	N		
Sept. 10, 1960			
0000	NW	NNW (340)	NNE
0005	NW		
0032	N		
0035	N		
0045	NE		
0054	NE		
0100	N		
0110	N		
0115	N	NW (310)	N
0128	NW		
0135	NW		
0200	N		
0227	NW		
0233	SW		
0240	SW	WNW (290)	NW
0255	SW		
0316	NW		
0322	N		

were reflected by corresponding deviations in the movement of the center. Table 2 illustrates the correlation achieved, and shows that for each clockwise change in direction of eye motion, the location of the intense echo area also shifted clockwise.

It was felt that study of other hurricane film was warranted. Carla was chosen because its almost cycloidal path indicated greater persistency and less erratic movement. The Carla film confirmed the conclusions reached in the Donna study. (See tables 3 and 4.) In addition, other facts became apparent. The Donna film studied dealt with an echo from a portion of the wall cloud covering about 180° of arc, with a bright spot or crescent-shaped area indicating the zone of maximum intensity. In Carla the echo from the wall cloud was completely around the eye. It was not difficult to determine from the film the most intense sector of the wall cloud. A comparison of these data (tables 3 and 4) confirmed the fact that the center moved in the direction of the most intense sector of the wall cloud.

Of equal importance was the observation that when the center fixes indicated no movement, the wall cloud appeared to be fairly equally intense in all sectors. This occurred during Carla at the cusps of the cycloid.

3. DISCUSSION

Because the study was made from film without any instrumental measurements, a fair amount of subjectivity was present. To minimize this condition, the tabulations were made independently by different observers and compared. Only minor differences were found.

Actual determination of the most intense sector of the wall cloud during the progress of a current hurricane

TABLE 2.—*A summary showing the correlation between the change in hurricane Donna track and the deviation in the intense sector*

Eye motion toward	Change*	Sector of intense area	Change*
NW		N	
W	−	NW	−
NW	+	N	+
W	−	NW	−
NW	+	NE	+
W	−	NNE	−
NW	+	NE	+
W	−	NNW	−
NNW	+	NE	+
WNW	−	NW	−
NNW	+	NNE	+
NW	−	N	−
WNW	−	NW	−

*Change in direction indicated by + when clockwise; by − when counterclockwise.

TABLE 3.—*Time and location of intense area in hurricane Carla wall cloud and deviation of eye and intense area*

Time (GMT)	Location of spot	Eye motion toward	Intense area sector	Time (GMT)	Location of spot	Eye motion toward	Intense area sector
Sept 10, 1961				1835	NNW		
1209	NE			1905	NW	WNW	NW
1220	ENE	NNW	NNE	1948	NW	(280)	
1230	NE	(340)		2028	E		
1235	NNE			2100	ENE		
1307	NNE			2133	NE	NNW	NE
				2149	NNE	(340)	
1320	N			2222	N		
1335	NNW						
1400	NNW			2240	NW		
1416	NNE			2340	SSW		
1430	N	NW	N				
1445	NNE	(320)		*Sept. 11, 1961*		NW	W
1500	N					(305)	
1527	NE			0000	SSW		
1545	NNE			0016	SSE		
1555	N						
				0059	SSW		
1607	NNW			0114	SSW		
1626	NW	WNW	NW	0132	SSW		
1700	N	(290)		0145	SSW	W	SSW
				0200	S	(270)	
1733	NNW	NW		0210	SSW		
1815	NW	(310)	NNW	0215	SSW		
				0225	SSE		

should be a simple operation. Gain reduction, or the use of the attenuators present in the WSR–57, should reveal the hard core of maximum intensity toward which the center would move. This movement will appear as a deviation in course from a previous position, and should correspond to the deviation in location of the intense area. Photographs of an attenuated wall cloud as seen on the radarscope during the passage of a tropical storm would provide an objective case history.

At times doubt has been expressed as to the accuracy of an eye fix which deviated sharply from some previous fix. With an evidenced display of a maximum intensity shift prior to the new eye fix, greater confidence could be given to the new position even though the change was on the order of a minor oscillation.

TABLE 4.—*A summary showing the correlation between the change in hurricane Carla track and the deviation in the intense area*

Eye motion toward	Change*	Sector of intense area	Change*
NNW		NNE	
NW	−	N	−
WNW	−	NW	−
NW	+	NNW	+
WNW	−	NW	−
NNW	+	NE	+
NW	−	W	−
W	−	SSW	−

*Change in direction indicated by + when clockwise; by − when counterclockwise.

REFERENCES

1. H. V. Senn, "Hurricane Eye Motion as Seen by Radar," *Proceedings of the Ninth Weather Radar Conference, Kansas City, Mo.*, 1961, pp. 1–5.
2. Tu-Cheng Yeh, "Motion of Tropical Storms Under the Influence of a Superimposed Southerly Current." *Journal of Meteorology*, vol. 7, No. 2, Apr. 1950, pp. 108–113.
3. G. E. Dunn and B. I. Miller, *Atlantic Hurricanes*, Louisiana State University Press, Baton Rouge, 1960, 326 pp. (See chap. 10.)
4. E. W. Hoover, "Devices for Forecasting the Movement of Hurricanes," U.S. Weather Bureau, Washington, D.C., Jan. 1957 (unpublished).
5. R. L. Pfeffer, "Further Examination of the Balance of Angular Momentum in the Mature Hurricane," *National Hurricane Research Project Report* No. 19, 1958, 15 pp.
6. T. Shibayama, "Forecasting the Movements of Typhoons by the 500–1000 mb. Thickness Charts," Japanese Defense Research Board, 1962, 8 pp.